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Context Model Based Onboard Data Processing and Compression

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State of Onboard Processing

- Limited to simple task in the past: co-adding
- Universal Lossless Compression developed/validated since '96, on > 15 missions
- New tunable compression under development
  - \> 20 Msamples/sec algorithm and RT ASIC
- Fourier Transform processor
  - Planned for GIFTS/EO-3

Limited onboard programmable processing power

Lack of algorithm specification by science team

Project Description

- **Objective:** utilize context information to develop algorithms for processing multi- and hyper-spectral data
  - ➔ improve compression performance
  - ➔ facilitate data fusion/mining, understanding needed for intelligent sensor/instrument control
- **Emphasis:** "implementability" of developed algorithms on "real" space-ready re-configurable processors
- **General Approach:**
  - Select meaningful "context" with science team
    - Cloud has been selected as the first contex
  - Develop onboard processing algorithm
  - Simulation on reconfigurable processor to obtain performance benchmark and evaluate results
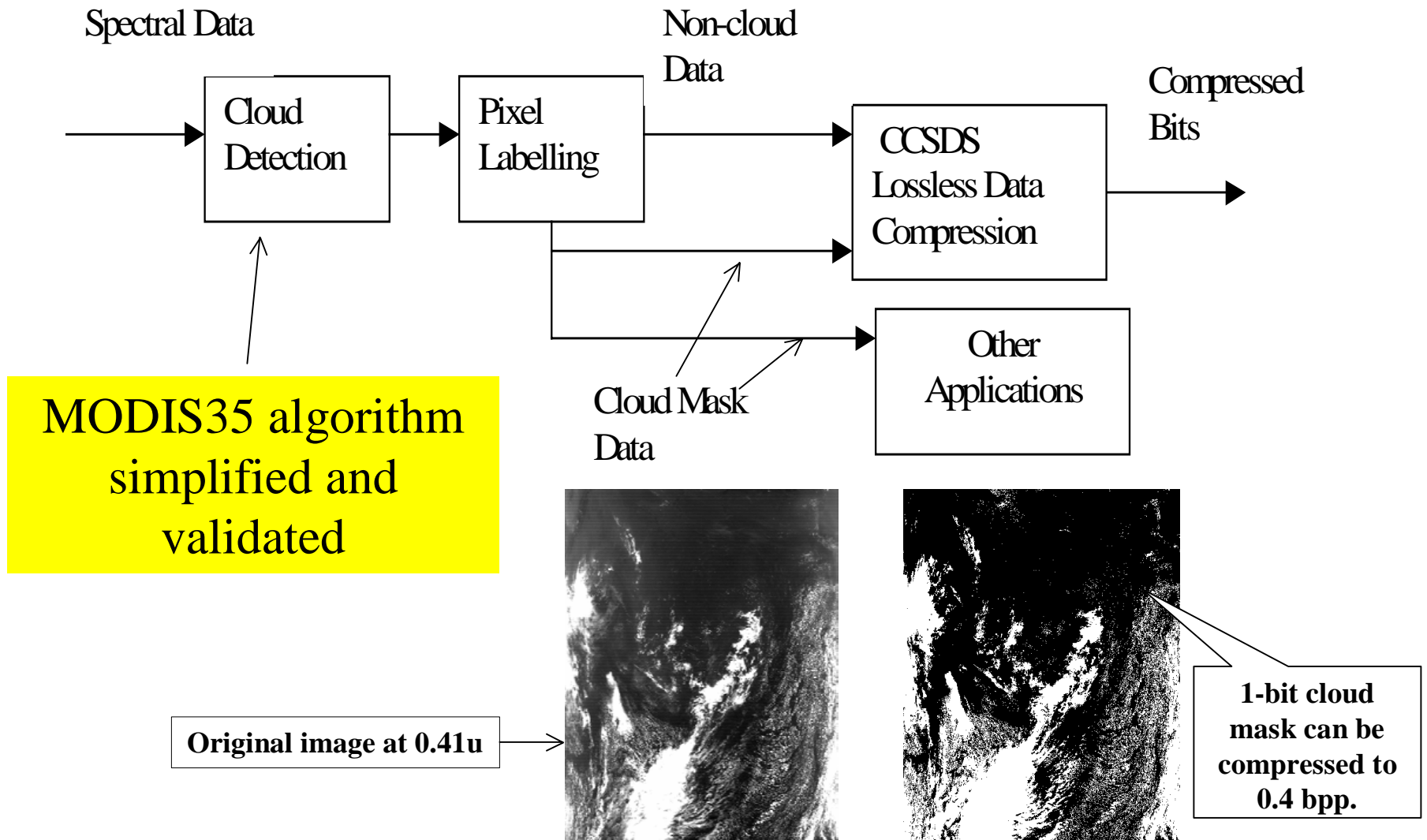
- **Spectral Feature Extraction for Context**
  - "cloud" detection based on multi-spectral data
    - Impact on lossless compression
    - Other applications: cloud height computation, percentage coverage within field of view, …

- **Spectral Information Representation**
  - Generic representation for hyperspectral data
    - Impact on lossless compression
    - Other applications: Detection of trace elements
  - "cloud" spectral representation

Spectral Feature Extraction for Cloud

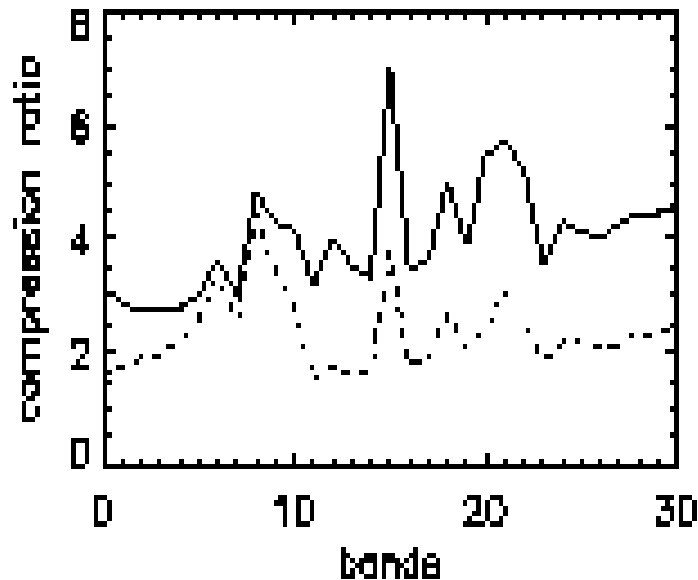Cloud Feature Detection and Compression Study

Spectral Data

Non-cloud Data

Compressed Bits

```
[Cloud Detection] → [Pixel Labelling] → [CCSDS Lossless Data Compression] → Compressed Bits
                         ↓
                    Cloud Mask Data → [Other Applications]
```

MODIS35 algorithm simplified and validated

Cloud Mask Data

Original image at 0.41u

1-bit cloud mask can be compressed to 0.4 bpp.

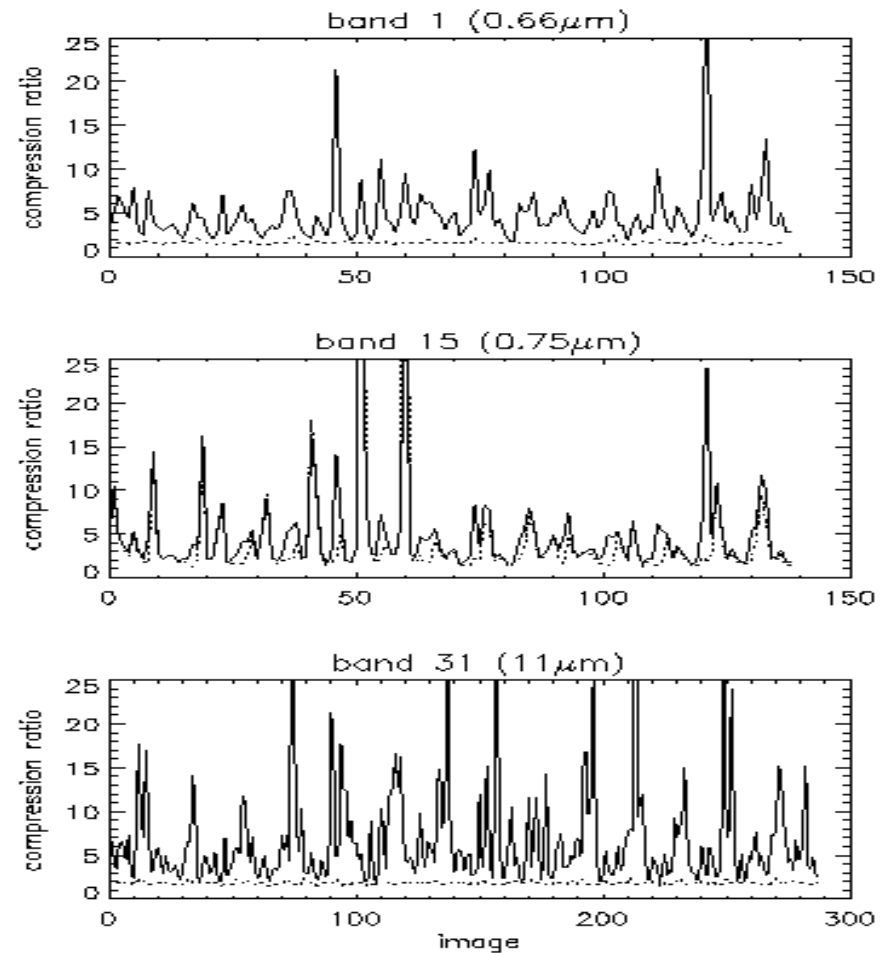# Compression Results Using Cloud Context

Results on L1A Data

Results on L1B Data

Compression improvement 40%

Note: --- without cloud context

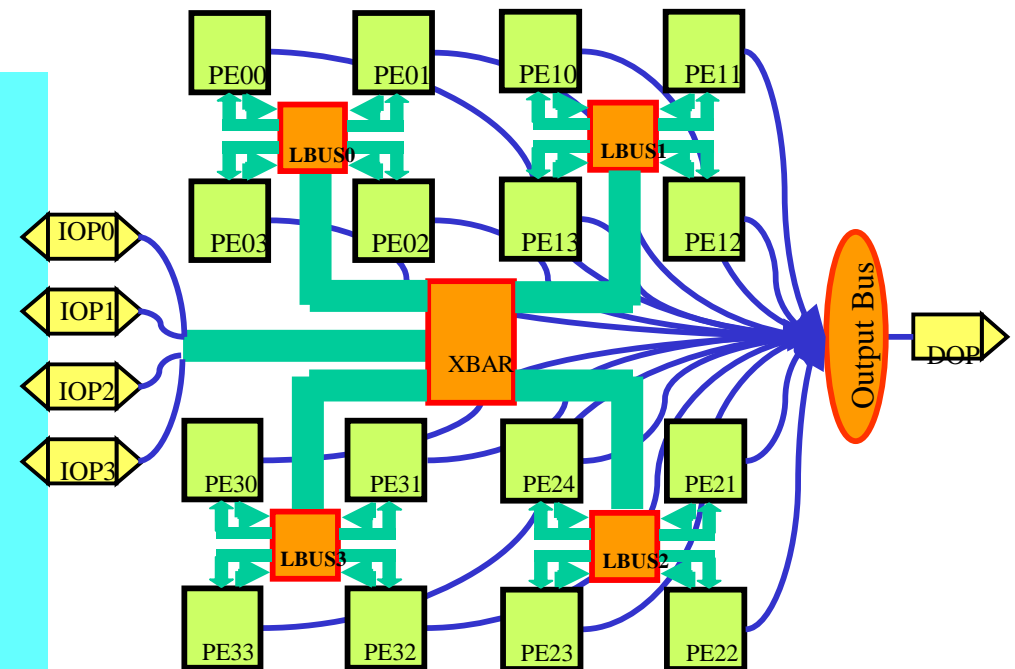_____ with cloud context

Compression improvement 60%

Implementation Study

- CPU and FPGA not best choice for Data Streaming computation
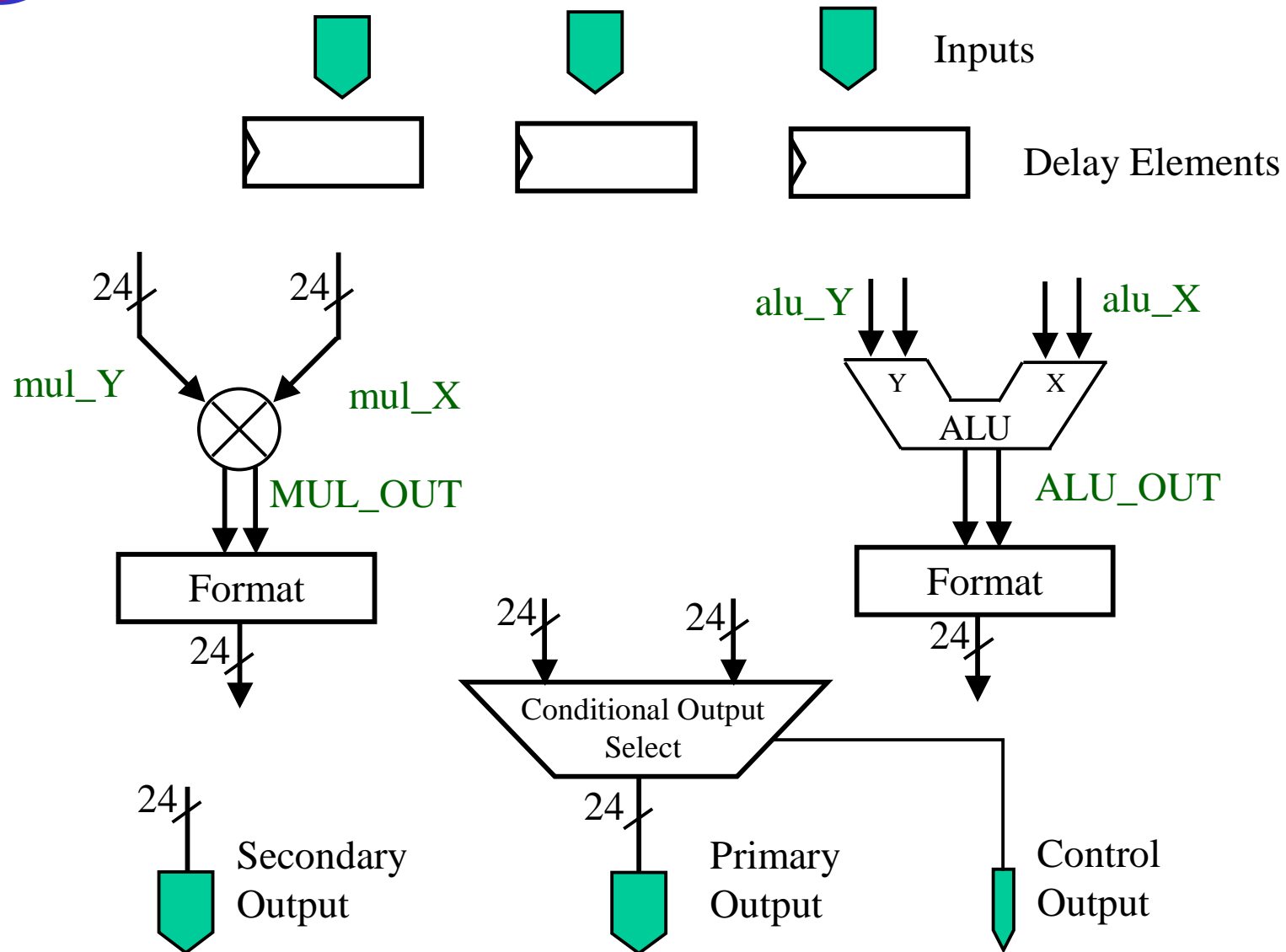- DSP not efficient enough

A new generation of radiation tolerant re-configurable processor: Field Programmable Processor Array (FPPA) has been in development

➔ Provides a "giant" leap forward in onboard processing capability needed in data fusion/understanding, situation analysis, sensor control, …..

First generation FPPA with 16 Processing Elements
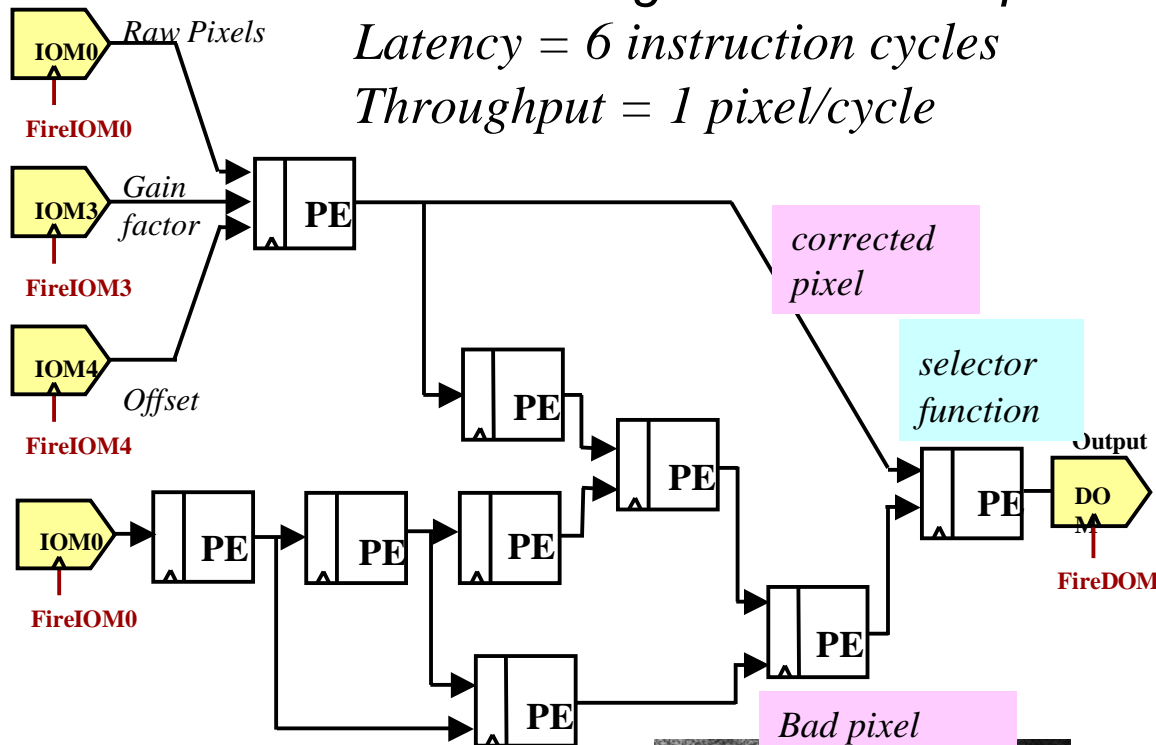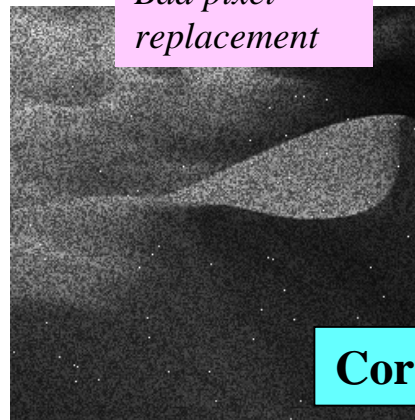
Processing Element Components

Inputs

Delay Elements

24 24

mul_Y mul_X

MUL_OUT

Format

24

alu_Y alu_X

Y X

ALU

ALU_OUT

Format

24

24 24

Conditional Output
Select

24

24

Secondary
Output

Primary
Output

Control
Output

FPPA example: Sensor Readout Correction

9 Processing Elements Required
Latency = 6 instruction cycles
Throughput = 1 pixel/cycle

Corrected

Simulated at over 50 Msamples/sec;

Example funded by FPPA development project

Original

Corrupted

Plans

- FPPA simulation: simplified cloud context detection algorithm

  – Challenges: multi-spectral input needed in conditional logic sequence

- Lossless compression study based on combined cloud feature extraction and spectral decomposition approach

- Explore: other context, other applications?

References

Zhou, Y. P, Yeh, P.-S., Wiscombe, W. and Tsay, S.-C., "Clould context-based onboard data compression", *Proc. IGARS 2003*, Toulouse, July 21-25, 2003

Donohoe, G and Yeh, P.-S, "Sensor Data Processing on a Reconfigurable Processor", *Proc. ESTO Conf., 2003*, College Park, MD, , June 24-26, 2003